

Dec. 18, 1934.

R. K. REYNOLDS

1,984,701

APPARATUS FOR AND METHOD OF SHRINKING AND FELTING

Filed Nov. 9, 1931

4 Sheets-Sheet 1

Fig. 1.

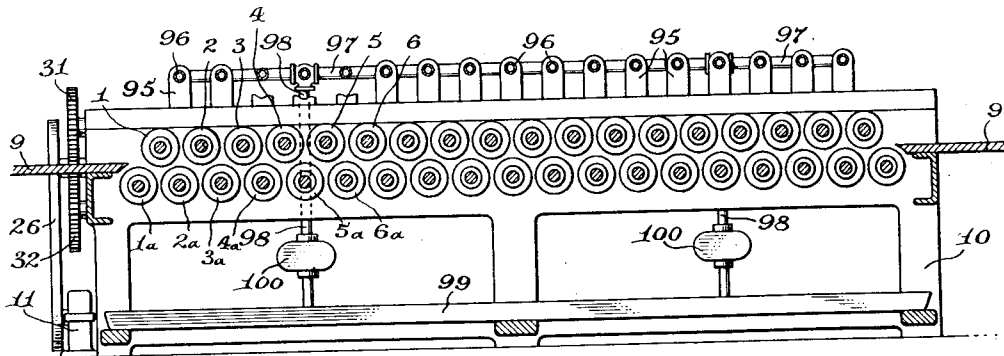


Fig. 2.

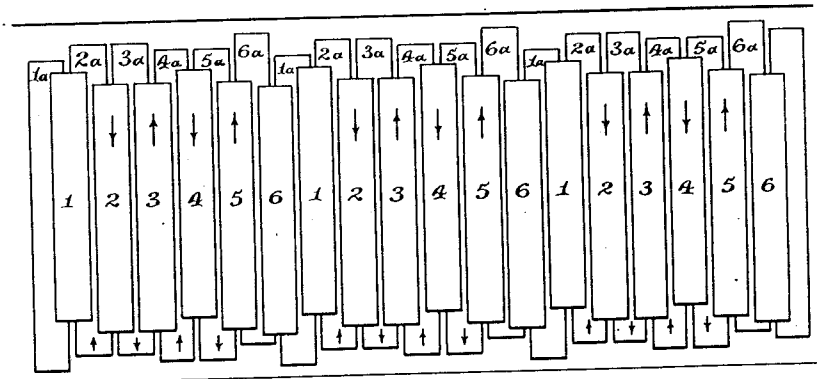


Fig. 3.

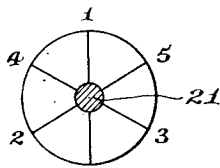
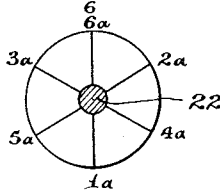


Fig. 4.



INVENTOR
Ralph H. Reynolds
 BY *Jamney, Blair & Carter*
 ATTORNEYS.

Dec. 18, 1934.

R. K. REYNOLDS

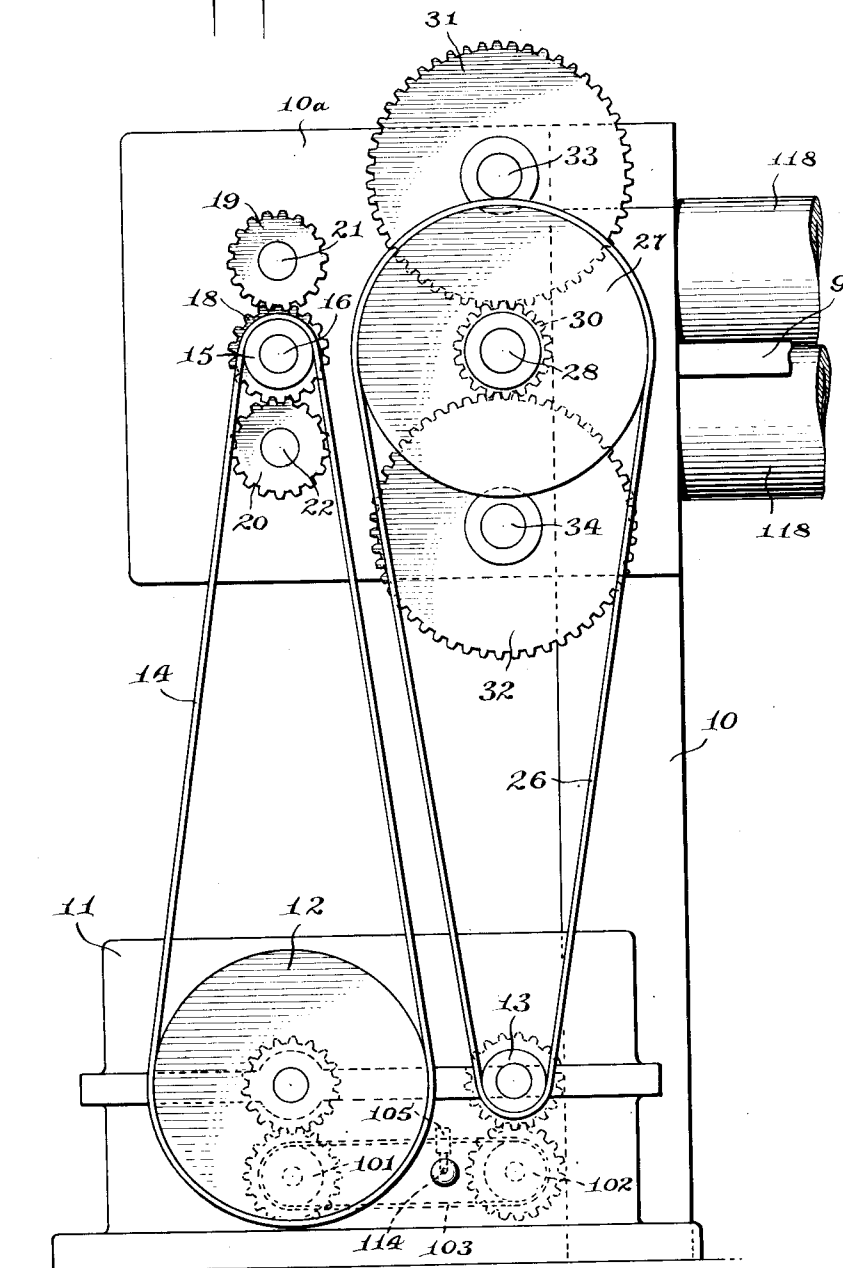
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4 Sheets-Sheet 2

Fig. 5.



INVENTOR

Ralph K. Reynolds

BY *his* ATTORNEY^S

Jarney, Blair & Curtis

Dec. 18, 1934.

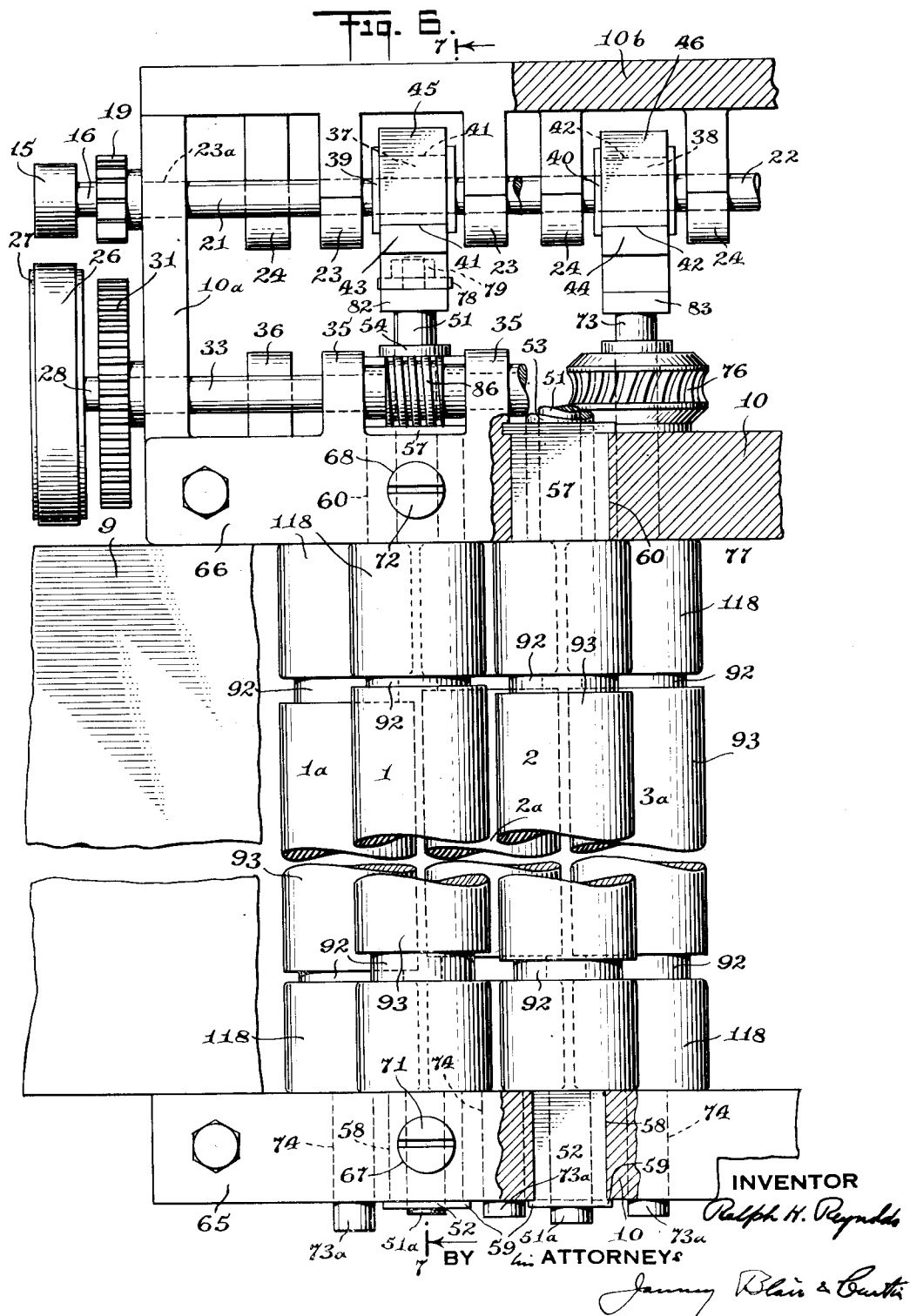
R. K. REYNOLDS

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APPARATUS FOR AND METHOD OF SHRINKING AND FELTING

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Dec. 18, 1934.

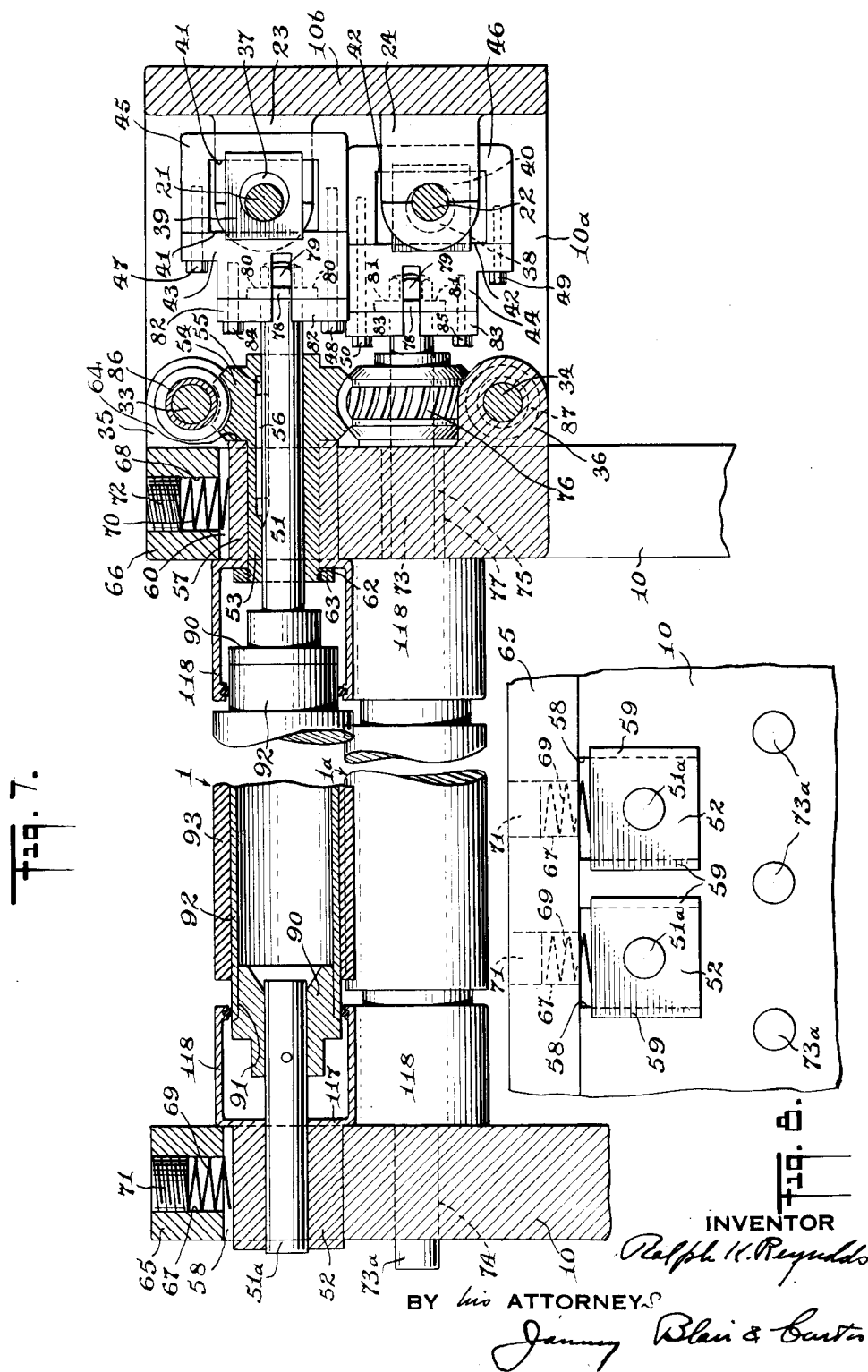
R. K. REYNOLDS

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APPARATUS FOR AND METHOD OF SHRINKING AND FELTING

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UNITED STATES PATENT OFFICE

1,984,701

APPARATUS FOR AND METHOD OF SHRINK-
ING AND FELTING

Ralph K. Reynolds, Danbury, Conn., assignor to
The Mallory Hat Company, Danbury, Conn., a
corporation of Connecticut

Application November 9, 1931, Serial No. 573,761

18 Claims. (Cl. 28—5)

The invention relates to apparatus for and a method of shrinking and felting articles made of fur or other fibres possessing felting properties.

5 One object of the invention is to provide a machine of the character indicated adapted to perform the felting or sizing operation efficiently. Another object of the invention is to provide a machine of the character indicated adapted to
10 finish the felting or sizing operation efficiently. Another object of the invention is to provide a machine of the character indicated adapted to form a firm and durable felt. Another object of the invention is to provide a machine of the character indicated adapted to perform a felting operation
15 quickly. Another object of the invention is to provide a machine of the character indicated of rugged and durable construction. Another object of the invention is to provide an improved method of felting. Another object of the invention is to provide a method of felting which
20 enables the production of a more durable product. Another object of the invention is to provide a method of felting which shall eliminate excessive handling of the articles to be felted and reduce
25 labor costs. Another object of the invention is to provide a method of felting which causes the shrinking and felting to be accelerated. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of said steps to
35 one or more of the others thereof, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is shown one of various possible embodiments of the mechanical features of this invention.

Figure 1 is a vertical sectional view of a machine constructed in accordance with the invention,
45

Figure 2 is a diagrammatic plan view showing the arrangement of the rollers in the machine,

Figures 3 and 4 are diagrams indicating the sequence of nodal points in the vibration of successive rollers,
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Figure 5 is an end elevation of the driving mechanism of the machine on an enlarged scale,

Figure 6 is a plan view of the roll rotating and oscillating mechanism,

55 Figure 7 is a vertical sectional view of the roll

rotating and oscillating mechanism, the section being taken on line 7—7 of Figure 6, and

Figure 8 is a fragmentary end elevation of a portion of the right-hand side of the machine.

Similar reference characters refer to similar parts throughout the several views of the drawings.

As conducive to a clear understanding of this invention, it is observed that the property of felting is a property existing in certain fibers, for example rabbit's fur, whereby when a mass of such fibers are laid together and properly treated, both chemically and mechanically, they interlock to form a fabric, and in so doing fore-
10 shorten, as a mass, both in length and breadth, and at the same time gain in thickness and density, still considering the fibers as a mass. Mechanical treatment to generate or assist the felting action has for a long time consisted in rolling or wrapping an article, such as a hat bat, and kneading it. Another method or manner of performing the mechanical part of felting has involved the passage of hat bats between reciprocating rollers, such as between an upper roller and a lower roller traveling in opposite direc-
15 tions. In these two examples of former methods and machines for imparting the mechanical energy to fibers in order to cause them to felt and shrink, as well as in many other methods and machines for the same purpose, the effect of the machine or method has been to knead the hat bodies, such kneading having been given various names to create distinctions between machines and methods, but essentially consisting in each case of bending of the plies of the hat bodies and deformation thereof, pulling and pushing of the hat bodies and the like.

The present invention involves a fundamentally different method of performing the mechanical part of the felting operation and a machine for carrying out the method, and also involves the use of one or more features of the new method and machine in combination with one or more features of already known methods and machines.
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Referring now to Figure 1, the machine herein illustrated, being a typical embodiment of the machine part of the present invention, is mounted on a suitable frame 10 having tables 9, 9 at either end thereof for the deposit of treated and untreated hat bats and the convenience of the operatives. Suitably journaled in the framework 10 of the machine, in a manner to be hereinafter more fully described, are a plurality of upper rollers 1, 2, 3, 4, 5 and 6; and a plurality
55

of lower rollers 1a, 2a, 3a, 4a, 5a and 6a. These rollers are arranged in staggered relation as indicated in Figure 1, are preferably of a light construction such as will be hereinafter described, are located fairly close together in order to reduce the possibility of hat bats moving out of their intended path, and are preferably of a diameter of the order of between two and four inches.

Referring now to Figure 5 in connection with Figure 1, at one end of the machine frame 10, for example at the front end thereof, is a gear box 11 containing suitable gears, not shown, actuated from a main driving shaft or any suitable source of power, the gearing in the gear box 11 serving to rotate pulleys 12 and 13 at a rate of speed, which, so far as the ultimate effects upon the rollers 1, 2, 3, 4, 5 and 6, and 1a, 2a, 3a, 4a, 5a and 6a are concerned, will hereinafter be fully indicated. Referring now to Figure 6 in connection with Figure 5, the pulley 12 is connected by means of a belt 14 to a small pulley 15 mounted on a shaft 16 which is journaled in a bearing, not shown, formed in a frame extension 10a of the machine frame 10. Referring now to Figure 5, fastened to the shaft 16 is a spur gear 18 which meshes with and drives an upper gear 19 and a lower gear 20, which are fastened to shafts 21 and 22 respectively. Referring now to Figure 6, the upper shaft 21 is journaled at 23a in the frame extension 10a, and also in bearings in a plurality of portions 23 extending inwardly from a side frame member 10b forming part of the frame of the machine. Similarly, the lower shaft 22 is journaled in the frame extension 10a, and also, as best shown in Figure 7, a plurality of portions 24 extending inwardly from the side frame member 10b under the portions 23. The shafts 21 and 22 constitute the upper and lower vibrating shafts respectively, being provided with individual eccentrics to separately vibrate the several rollers 1 to 6 and 1a to 6a, as will be hereinafter fully described. Preferably the drive for the shafts 21 and 22 is duplicated at either end of the machine in order to reduce torsional strain on the shafts, and in case a large number of rollers 1 to 6, and 1a to 6a are used, the shafts 21 and 22 may be divided into sections and separately driven.

Referring again to Figure 5, the pulley 13, by means of a belt 26, drives a large pulley 27 which is fastened to a shaft 28 that is journaled in a bearing 29 formed in the frame extension 10a. Also fastened to the shaft 28 is a pinion gear 30 which meshes with large gears 31 and 32 fastened to shafts 33 and 34 respectively, constituting the upper and lower of the roll rotating shafts, for the rotation of the several rollers 1 to 6 and 1a to 6a. As indicated in Figures 5, 6 and 7, the shafts 33 and 34 are journaled in the frame extension 10a and are further supported by journals in a plurality of portions 35 and 36 extending outwardly from the frame 10.

Referring now to Figure 7, which is illustrative of the operating connections for rotating and vibrating all of the upper and lower rollers 1 to 6 and 1a to 6a, the shafts 21 and 22 have secured thereto a series of eccentrics 37 and 38 respectively. The eccentrics 37 and 38 are respectively located in sliding blocks 39 and 40, which fit respectively in cross head guideways 41, 41 and 42, 42. The guideways 41, 41 are formed in members 43 and 45 which together constitute yokes, and the guideways 42, 42 are formed in members 44 and 46 which likewise form yokes of similar construction to the yokes 43, 45. The yoke members

43 and 45 are secured together by means of bolts 47 and 48, and the yoke members 44 and 46 are secured together by means of bolts 49 and 50.

As the shafts 21 and 22 rotate at a high rate of speed, the eccentrics 37 and 38 oscillate the blocks 39 and 40 rapidly. The vertical component of oscillation of the blocks 39 and 40 simply moves them up and down on the raceways 41, 41 and 42, 42, without using up any great amount of energy. The horizontal component of the oscillatory movement, however, is imparted to the yokes 43, 45 and 44, 46, by reason of the fact that the blocks 39 and 40 can not move horizontally in the raceways, and this horizontal component is transmitted to rollers, for example to the rollers 1 and 1a, as illustrated in Figure 7.

Still referring to Figure 7, which shows in detail the construction of and support for the rollers aforesaid, as typical of the construction of and means of support for all of the rollers, a roller shaft 51a is supported by a journal block 52 at one side of the machine. At the other side of the machine a roller shaft 51 extends through a sleeve 53 having a worm gear 54 formed thereon. The sleeve 53 has formed therein a key slot 55, and the shaft 51 is splined; a feather or key 56 is received in the key slot 55 and the spline, compelling the shaft 51 to rotate when the sleeve 53 is rotated, but permitting the shaft 51 to be reciprocated with respect to the sleeve 53. The sleeve 53 is journaled in a journal block 57. Referring now to Figures 7 and 8, the journal blocks 52 fit in square guideways 58 formed in the machine frame 10 which guideways allow a limited amount of vertical movement of the blocks 52. At either end of the blocks 52 are side flanges 59 to retain the blocks 52 in position in the guideways 58. The blocks 57 fit in similar square guideways 60 and have similar side flanges, not shown. In order to prevent relative longitudinal movement between the sleeve 53 and the blocks 57, one end of the sleeve 53 is threaded as shown at 62, and nuts 63 are secured thereto, the other end of the blocks 57 abutting shoulders 64 of the worm gear portions 54.

After the several blocks 52 and 57 are placed in the guideways 58 and 60, top plates 65 and 66 are secured to the top of the frame 10. A plurality of bores 67 and 68 are formed respectively in the top plates 65 and 66 in line with the guideways 58 and 60, and springs 69 and 70 are located therein urging the blocks 52 and 57 downwardly, the springs being retained in position and backed up by threaded plugs 71 and 72 which are secured into threaded portions of the bores 67 and 68. Thus the rollers 1, 2, 3, 4, 5 and 6 are resiliently mounted in the machine frame so as to be capable of a limited amount of vertical movement therein. Shafts 73a and 73 for the rollers 1a, as well as for the rollers 2a, 3a, 4a, 5a and 6a, are mounted respectively in plain bearings 74, and in sleeves 75 having worm gear portions 76, the sleeves 75 being connected to the shafts 73 by splined connections, not shown, which may be the same as those connecting the shafts 51 with the sleeves 53. The sleeves 75 are mounted in an unmovable journal portion 77 in the machine frame 10.

For transmission of the vibratory motion of the yokes 43, 45 to the shafts 51, and of the yokes 44, 46 to the shafts 73, each of said shafts has secured on the end thereof a washer 78 by means of a nut 79 screwed onto the reduced portion of the shaft, the washers 78 being received between segmental recesses 80, 80 and 81, 81 respectively provided in the yoke portions 43 and 44, and arcuate blocks

82, 82 and 83, 83 secured to the respective yoke portions 43 and 44 by means of the bolts 48 and 50 already referred to and additional bolts 84 and 85.

Referring to Figures 6 and 7, the worm gears 54 and 76 are rotated by worms 86 and 87 respectively secured on the shafts 33 and 34 and located between the journal extensions 35 and 36. These worms 86 and 87 mesh with respective worm gears 54 and 76, and in the case of the worms 86 and worm gears 54 a limited amount of relative vertical movement between them is possible without creating undue friction or disengaging them. In this manner the shafts 51 and 73 are revolved, thus revolving the several sets of rollers.

Still referring to Figure 7, which illustrates in detail the construction of the roller 1, which is typical of a preferred form of construction for the rollers 2 to 6 inclusive, as well as the rollers 1a to 6a inclusive, on the shafts 51 and 51a and suitably secured to them are roller ends 90, 90 having reduced portions 91. Mounted on the reduced portions 91 and rigidly connecting the roller ends 90, 90 is a metal cylinder 92. The tubular shaft or cylinder 92 has thereon a covering 93 which may be of rubber or other suitable material.

In order to keep oil which lubricates the bearings of the shaft 51 and 51a from reaching the cam 93 of the rollers I provide sleeves 117 having stuffing boxes 118 engaging the roller ends 90 as shown in section in Fig. 7.

From the foregoing description it is evident that the several rollers 1 to 6 and the several rollers 1a to 6a are all positively rotated and at the same time vibrated along their axes. As illustrated in Figure 1, there may be a plurality of sets of rollers 1 to 6 and 1a to 6a. The relative positions of any two rollers depend upon the angular position of the several eccentrics 37 on the shaft 21 and the angular position of the several eccentrics 38 on the shaft 22. Referring now to Figures 2, 3 and 4, there is therein indicated diagrammatically a preferred phase relationship between the several rollers with respect to their vibratory movement for machines having six upper and six lower rollers or multiples thereof. It is noted that in Figure 2 the upper rollers are foreshortened so as to permit the lower rollers to stand out clearly and that one roller of the lower bank (preferably the last one) may be a non-vibrating or dummy roller so as to maintain the even multiple relationship.

Figure 3 shows the phase relationship of the vibratory motion of the rollers 1 to 6, and Figure 4 shows the phase relationship of the vibratory motion of the lower rollers 1a to 6a. In each case the circle represents 360° of movement of the shaft 21 or the shaft 22 and on that circle is indicated by the radial lines the position of the extreme radius of the eccentrics 37 and 38 on the shafts, the numbers indicating the rollers by number which the several eccentrics control. Thus, when the roller 1 is at one extreme end of its movement, the roller 2, in angular phase, has moved 120°, and the roller 3 has moved 240°, while the roller 4 has moved only 60°, the roller 5 has moved 300°, and the roller 6 has moved 180°. The same relationship exists in the case of the rollers 1a to 6a inclusive, as shown in Figure 4, and it is noted that the phase relationship of roller 1 to roller 1a is 180°. The positions of the rollers are indicated in Figure 2, and the relative movement thereof is indicated by the arrows. Those rollers having no arrows are at the ex-

treme limits of motion, except in the case of one roller of the lower bank (preferably the last one) which may be a non-vibratory or dummy roller, so as to maintain the even multiple relationship.

By describing a particular phase relationship of the vibratory motion of the several rollers it is not to be inferred that only this particular phase relationship may be successfully used. That phase relationship shown is a preferred phase relationship for rollers arranged in multiples of six and it is noted that in case the number of rollers is a multiple of some other number, the phase relationship may be arranged on a different basic angle. For example, with eight or multiples of eight upper and lower rollers, the phase relationship would preferably be arranged on a basic angle of ninety degrees. Advantages of moving the rollers in a phase relationship of the type indicated are that with respect to two contacting rollers they are sometimes moving together and sometimes moving oppositely, and with respect to each other are moving at varying speeds and have very little of a tendency to tear the hat bodies, and, on the other hand, a great tendency to vibrate the individual fibres. Furthermore, I am able to obtain a vibratory action of the rollers of the order of from 800 to 1200 complete reciprocations a minute of each roller, partly on account of the fact that the inertia of the rollers is balanced and no great strain is put upon any one portion of the machine, partly by reason of the light construction of the rollers adapted, and partly by reason of the efficient vibratory mechanism described. In accordance with certain features of the invention, the amplitude of vibration of the rollers, is of the order of from one-sixteenth of an inch to one quarter of an inch. The angular phase relationship disclosed is one example of a phase relationship such that the angularly adjacent actuating devices have intervening between them other actuating devices. The actuating devices referred to herein are the eccentrics 37 and 38 and by the foregoing I mean that the eccentrics for shafts 1 and 4, which as shown in Figure 3 are angularly adjacent, having intervening between them eccentrics Nos. 2 and 3, as the members on Figure 3 represent the order, linearly, of the eccentrics, this order being the same as the order of the rollers.

Referring now to Figure 1, extending upwardly from the frame 10 on either side of the machine are a plurality of brackets 95 supporting a plurality of pipes 96 which are located directly above the lower rollers 1a to 6a and thus between the rollers 1 to 6. Pipes 96 are supported by main pipes 97 having feeders 98, and in connection with this description it should be understood that any other means of supporting the pipes and any other system of piping may be substituted for that shown.

The piping system described supplies hot water to the hat bats or other articles being sized or undergoing the felting operation in the machine. Preferably the sizing water is collected in a basin 99 under the rollers and is circulated through the machine by means of pumps 100.

Hat bats or other articles to be felted are fed into the machine at one end thereof, and preferably the operator feeds them into the machine in shingled relationship, the tip of each hat bat, or the part of each hat bat which is first introduced into the rollers being covered by the base or rear portion of the preceding hat bat. The hat bats emerge from the other end of the machine and

pile up upon one of the tables 9, whereupon they may be fed into the rollers of another smaller machine located parallel to the first machine but adapted to feed the bats in the opposite direction, or they may be otherwise disposed of. Desirably the hat bats are crozed after each passage through the machine, although it is noted that many of the features of this invention are adapted for machines which perform a crozing operation automatically.

The action of the rollers upon hat bats traveling through the machine is a vibratory one and not a tearing action, for the reasons already set forth. This vibratory motion reaches the individual fibres of the felting mass of fur and stirs them with relation to each other, causing them to felt rapidly, and it is quite different from a mere kneading of or folding of the hat bats. The vibratory action is fast enough to affect the individual fibres by the inertia thereof, where a slower reciprocation has no effect upon them by reason of their inertia but can act only to pull one of them with respect to others.

Felting of fur by the vibratory method described is unusually rapid. If desired I may substitute a dye liquor for water in the basin 99 and circulating through the pipes 96, 97 and 98, thus dyeing the hat bats as they are being felted or sized. The dyeing of hat bats in felting machines is not per se new, but I note that according to prior methods and in prior machines the combining of the dye and sizing operations has not been completely satisfactory, because of the fact that the dyeing proceeded by a much faster rate than the sizing. Thus the hat bats would be completely dyed before being completely sized, and the further felting which was required and had to be performed had a deleterious effect on the color of the hat bats. According to the present invention sizing and felting is very rapid and it is possible to time the machine so that the dyeing and sizing are completed substantially simultaneously, resulting in a greatly improved hat bat.

In order that the dyeing and felting may be synchornized I preferably provide variable speed driving means in the gear box 11, which may take any form being herein illustrated by a pair of cones 101 and 102 having a belt 103 connecting them whereby the rate of revolution of the pulley 13 may be varied with respect to the rate of revolution of the pulley 12, there being a manually-controlled rod 114 having a fork 105 thereon for the shifting of the belt. I also contemplate the varying of the speed of the machine as a whole which may be done in any desired manner or by any desired mechanism not shown.

As an illustrative embodiment of the rate of operation of the machine, assuming the rollers to vibrate at between 800 and 1200 complete reciprocations per minute, the gearing in the box 11 is preferably arranged to rotate the rollers at that speed which will give a linear speed of the hat bats of between twenty and twenty-five feet per minute. Thus assuming that two inches of each hat bat is contacted in a linear direction by each roller, there will be more than six complete reciprocations of each roller with a given portion of a hat bat between the time of first engagement with that roller and the separation therefrom. There is accordingly exerted upon the hat bats a much greater amount of friction and vibration in a machine constructed in accordance with the present invention and according to the present method than in prior machines and methods, particu-

larly when the hat bats are fed into the machine in shingled relationship.

It should be noted that by reciprocating the rollers individually and by arranging the reciprocation thereof so that no great number of rollers is simultaneously moving in one direction, or simultaneously reversed, wear of the machine is greatly reduced and this feature of the invention may be incorporated in various types of felting machines. Other features of the machine may be used in connection with machines of generally different types, and the method of the invention may be carried out in a totally different machine from that described. It will thus be seen that there has been provided by this invention a method and apparatus in which the various objects hereinabove set forth, together with many thoroughly practical advantages, are successfully achieved.

As various possible embodiments might be made of the mechanical features of the above invention, and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter herein set forth, or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a multiroller felting machine for the treatment of hat bats and the like, the combination with a bank of upper rollers, and a bank of lower rollers, of a shaft to vibrate axially the upper rollers, a shaft to vibrate axially the lower rollers, a plurality of roller vibrating devices on the first named shaft, a plurality of roller vibrating devices on the second named shaft, the extreme throw of said devices being located in different angular positions on each of said shafts, to effect a balance of the endwise momentum of said rollers and means for rotating said rollers.

2. In apparatus for felting, in combination, a bank of rollers comprising a plurality of rollers positioned side by side, means adapted to rotate said rollers, a second bank of rollers comprising a plurality of rollers positioned side by side and disposed over said first bank, means adapted to rotate the rollers of said second bank, means adapted to reciprocate the rollers of one of said banks at such respective times and speeds that the momentum of all of said rollers of that bank will always be in balance, and means adapted to reciprocate the respective rollers of the other bank at such timing and speeds that the momentum of all rollers of that bank will always be in balance.

3. In apparatus for felting, in combination, a plurality of banks of rollers, the rollers of each bank being horizontally disposed side by side, the rollers of each bank being so closely spaced one from the other as to direct a hat bat automatically between the banks from end to end thereof, and means adapted to impart a reciprocating movement in an axial direction to the respective rollers of each of said banks, such movements being so timed as to neutralize the aggregate end thrust of the rollers caused by their reciprocation.

4. In apparatus for felting, in combination, a plurality of banks of rollers, the rollers of each bank being horizontally disposed side by side, the rollers of each bank having their axes laterally offset with respect to the axes of the other bank, and the rollers of each bank being so closely spaced one from the other as to direct a hat bat automatically between the banks from end to end thereof, and means adapted to impart an indi-

vidual reciprocating movement in axial directions to the respective rollers of said banks, the axial movement of rollers of one bank being out of synchronism with the axial movement of adjacent rollers on the other bank.

5. In apparatus for felting, in combination, a plurality of banks of rollers, the rollers of each bank being horizontally disposed side by side, the rollers of each bank having their axes laterally offset with respect to the axes of the other bank, and the rollers of each bank being so closely spaced one from the other as to direct a hat bat automatically between the banks from end to end thereof, and means adapted to impart a reciprocating movement in an axial direction to the respective rollers of each of said banks, such movements varying in phase throughout the rollers of each of said banks.

6. In apparatus for felting, in combination, a plurality of banks of rollers, the rollers of each bank being horizontally disposed side by side, the rollers of each bank having their axes laterally offset with respect to the axes of the other bank, and the rollers of each bank being so closely spaced one from the other as to direct a hat bat automatically between the banks from end to end thereof, and means adapted to impart a reciprocating movement in an axial direction to the respective rollers of each of said banks, the movements of the rollers of each bank being so timed as substantially to neutralize the end thrust due to momentum of each bank independently of the momentum of the other bank of rollers.

7. In apparatus for felting, in combination, a pair of banks of rollers mounted side by side, said banks being disposed one above the other, means adapted to rotate said rollers about their axes, the rollers of each bank comprising one or more groups of rollers, and means adapted to reciprocate the rollers of each group, one half of the rollers of each group having a phase relationship each equally spaced from the other, and the other half of the rollers of that group having a phase relationship each equally spaced from the other, the reciprocation of the rollers of each half group being out of synchronism with that of the rollers of the other half of that group.

8. In apparatus for felting, in combination, a bank of rollers mounted side by side, means adapted to rotate said rollers about their axes, means adapted to guide a plurality of hat bats along said rollers and in contact therewith, the rollers of said bank being divided into a plurality of groups of four or more rollers, and means adapted to reciprocate the rollers of each group, one half of the rollers of each group having a phase relationship each equally spaced from the other, and the other half of the rollers of that group having a phase relationship each equally spaced from the other, the reciprocation of each of the rollers of each group being out of synchronism with the other rollers of that group.

9. In apparatus for felting, in combination, a pair of banks of rollers mounted side by side, said banks being disposed one above the other, means adapted to rotate said rollers about their axes, the rollers of each bank comprising one or more groups of rollers, and means adapted to reciprocate the rollers of each group, one half of the rollers of each group having a phase relationship each equally spaced from the other, and the other half of the rollers of that group having a phase relationship each equally spaced from the other, the reciprocation of the rollers of each half group being out of synchronism with that of the rollers

of the other half of that group, the phase relationship of the rollers of one of said banks being opposite to the phase relationship of the rollers of the other of said banks.

10. In apparatus for felting, in combination, a pair of banks of rollers mounted side by side, said banks being mounted one above the other, means adapted to rotate said rollers about their axes, the rollers of each bank comprising one or more groups of rollers, and means adapted to reciprocate the rollers of each group in phase relationship, one half of the rollers of each group being spaced in phase a number of degrees equal to 360 divided by the number of that half group, and the other half of said group having its rollers spaced in phase one from the other to the same extent and spaced in phase with respect to the first half group by an angular distance equal to 360° divided by the total number of the rollers of the group.

11. In apparatus for felting, in combination, a bank of rollers mounted side by side, means adapted to rotate said rollers about their axes, means adapted to guide a plurality of hat bats along said rollers and in engagement therewith, said bank of rollers being divided into a plurality of groups of four or more rollers, and means adapted to reciprocate the rollers of each group, one half of the rollers of each group being spaced in phase a number of degrees equal to 360 divided by the number of that half group, and the other half of said group having its rollers spaced in phase one from the other to the same extent and spaced in phase with respect to the first half group by an angular distance equal to 360° divided by the total number of rollers of that group.

12. In apparatus for felting, in combination, a pair of banks of rollers mounted side by side, said banks being disposed one above the other, means adapted to rotate said rollers about their axes, the rollers of each bank comprising one or more groups of rollers, means adapted to reciprocate the rollers of each group in phase relationship, one half of the rollers of each group being spaced in phase a number of degrees equal to 360 divided by the number of that half group, and the other half of said group having its rollers spaced in phase one from the other to the same extent and spaced in phase with respect to the first half group by an angular distance equal to 360° divided by the total number of the rollers of the group, and means for similarly reciprocating the rollers of each of the groups of the banks.

13. In felting apparatus, in combination, a plurality of banks of rollers positioned side by side and spaced to receive and carry a hat therebetween from end to end of the banks, means adapted to rotate the rollers of each bank, and means adapted to reciprocate endwise the rollers of each bank, the reciprocation of the rollers of one bank being out of phase with each other, and the reciprocation of the rollers of each bank as a whole being substantially 180° out of phase with adjacent rollers of the opposite bank.

14. In apparatus for felting, in combination, a bank of rollers mounted side by side, means adapted to rotate said rollers about their axes, means adapted to guide a plurality of hat bats along said rollers and in contact therewith, the rollers of said bank being divided into a plurality of groups of four or more rollers and the rollers of said bank being so closely spaced as to cause a hat bat to travel therealong without passing between individual rollers, and means adapted to reciprocate the rollers of each group, one half

of the rollers of each group having a phase relationship each equally spaced from the other, and the other half of the rollers of that group having a phase relationship each equally spaced from the other, the reciprocation of each of the rollers of each group being out of synchronism with the other rollers of that group.

15. In apparatus for felting, in combination, a frame, a bank of rollers positioned side by side and having their end shafts rotatably mounted in said frame, a second bank of rollers positioned side by side and disposed over said first bank and having their end shafts rotatably mounted in said frame, gear parts keyed to one end shaft of each of said rollers to allow for relative axial movement therebetween, driving means for said gear parts, and cam means for imparting axial individual reciprocation to each of the rollers of each of said banks at such respective times and speeds that the momentum of all of said rollers will always be in balance during the operation of said cam means.

16. In apparatus for felting, in combination, a frame, a bank of rollers positioned side by side and having their end shafts rotatably mounted in said frame, a second bank of rollers positioned side by side and disposed over said first bank and having their end shafts rotatably mounted in said frame, gear parts keyed to one end shaft of each of said rollers to allow for relative axial movement therebetween, driving means for said gear parts, cam means for imparting axial individual reciprocation to each of the rollers of each of said banks at such respective times and speeds that the momentum of all of said rollers will always be in balance during the operation of said cam means, and means for controlling the speed of reciprocation of said rollers and the speed of rotation of said rollers.

17. In apparatus for felting, in combination, a frame, a plurality of rollers mounted side by side in a bank in said frame, gear parts keyed to each of said rollers to allow for axial relative movement between said gear parts and said rollers, driving means for said gear parts, a shaft rotatably mounted in said frame and having its axis substantially at right angles to the axes of said rollers, a plurality of eccentrics mounted on said shaft, one opposite each of said rollers, and members rotatably connected with said rollers and embracing said eccentrics whereby upon rotation of said shaft reciprocation is imparted to each of said rollers, the eccentrics being so shaped with respect to each other as to reciprocate said rollers at such respective times and speeds that the momentum of all of said rollers will always be in balance.

18. In apparatus for felting, in combination, a frame, a plurality of rollers mounted side by side in a bank in said frame, gear parts keyed to each of said rollers to allow for axial relative movement between said gear parts and said rollers, a worm shaft meshing with said parts, a shaft rotatably mounted in said frame and having its axis substantially at right angles to the axes of said rollers, a plurality of eccentrics mounted on said shaft, one opposite each of said rollers, and members rotatably connected with said rollers and embracing said eccentrics whereby upon rotation of said shafts reciprocation and rotation is imparted to each of said rollers, the eccentrics being so shaped with respect to each other as to reciprocate said rollers at such respective times and speeds that the momentum of all of said rollers will always be in balance.

RALPH K. REYNOLDS.